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(54) **DAMPER DEVICE AND STEERING DEVICE**

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(Continued)

(58) **Field of Classification Search**
CPC B62D 7/163
See application file for complete search history.

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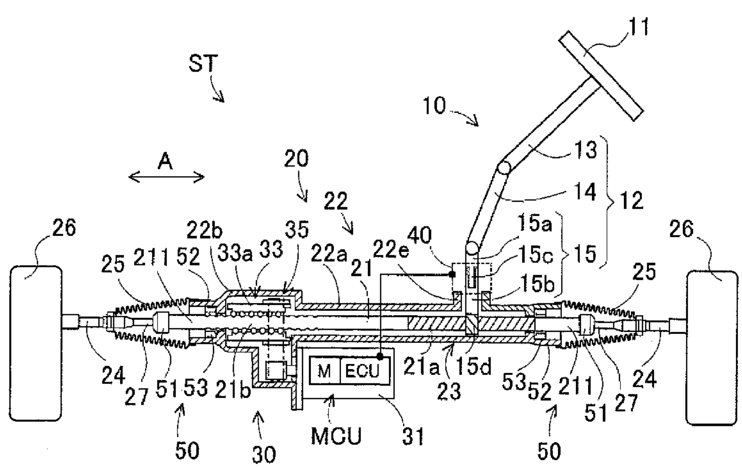
Primary Examiner — Terence Boes
(74) *Attorney, Agent, or Firm* — Oliff PLC

(57) **ABSTRACT**

In the damper device, when the large diameter portion does not apply an impact force on the flange portion, the elastic body is disposed in one of the housing and the cylindrical portion with a gap and when the large diameter portion applies the impact force on the flange portion, the elastic body is compressed by the restricting surface and the flange portion in an axial direction to be deformed into a state that the elastic body is brought into contact with all of the housing, the restricting surface, the cylindrical portion and the flange portion to be filled in the gap. The impact receiving member is restricted from a movement relative to the housing by the deformed elastic body when the end portion of the cylindrical portion is advanced into the relief portion and the impact receiving member keeps a non-contact state with the housing.

4 Claims, 6 Drawing Sheets



(51) **Int. Cl.**

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F16F 1/373	(2006.01)
F16F 1/44	(2006.01)
B62D 5/04	(2006.01)

(52) **U.S. Cl.**
CPC ***F16F 1/445*** (2013.01); *B62D 5/0421* (2013.01); *B62D 5/0448* (2013.01)

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FIG.1

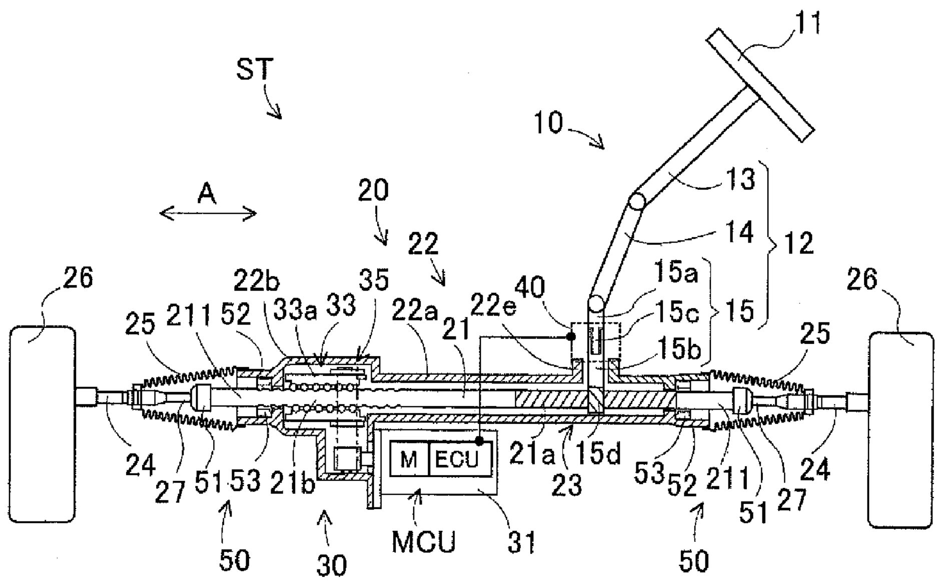
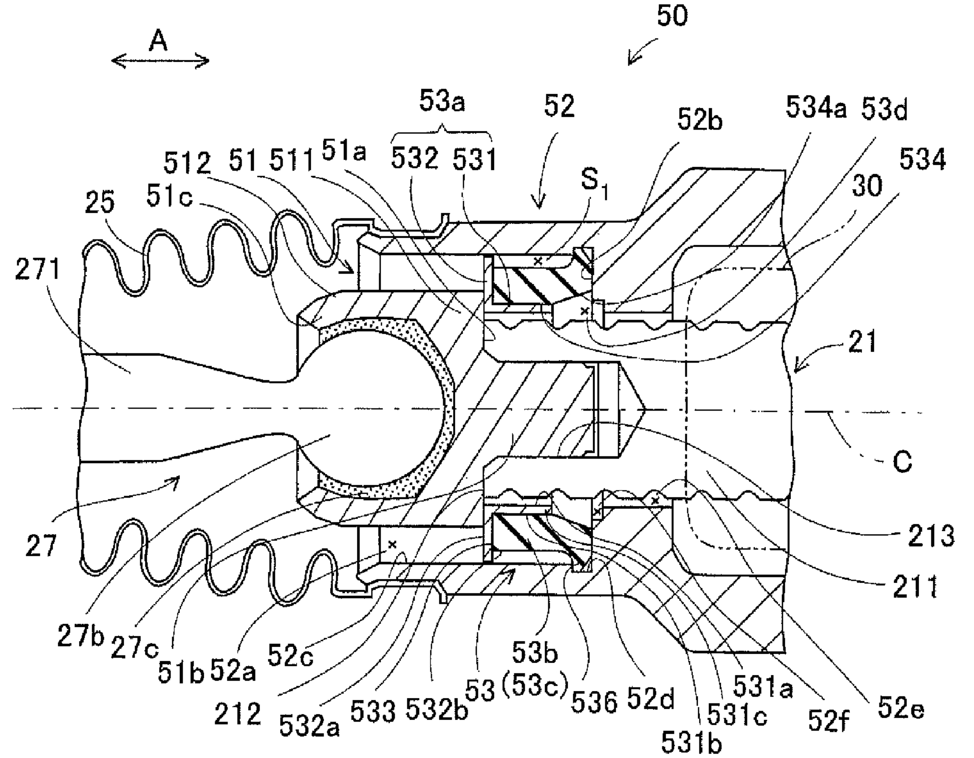

ST
A
20
22
10
11
13
14
12
15a
15c
15
15b
26
25
211
52
22b
33a
33
35
22a
21
22e
40
24
27
51
53
21b
M
ECU
21a
15d
23
50
30
MCU
31

FIG.2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A
53a
52
52b
534a
53d
534
30
512
51
511
51a
532
531
S1
25
51c
271
21
C
213
211
27
27b
27c
51b
52a
52c
212
532a
533
532b
53
53b
(53c)
536
52d
531a
531c
531b
52f
52e

FIG.3

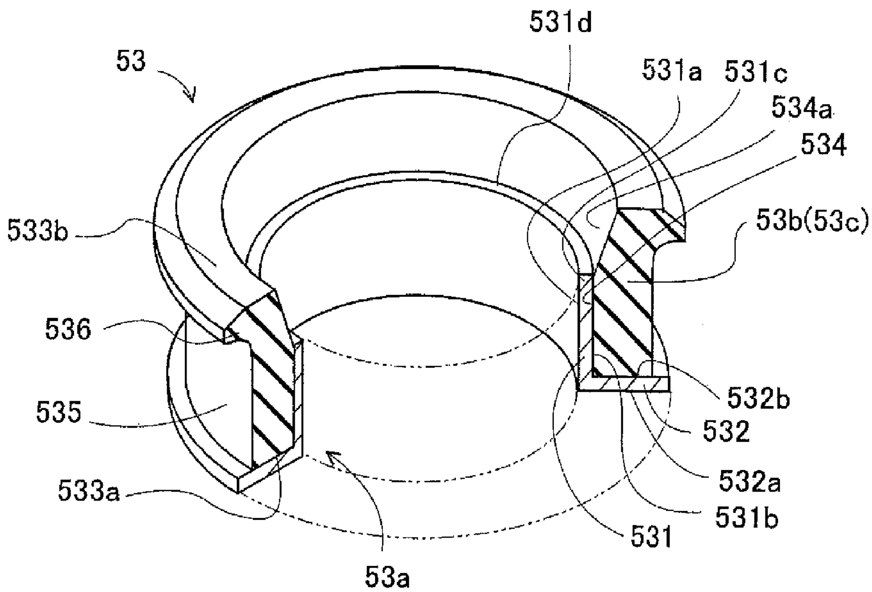

531d
53
531a
531c
534a
534
533b
53b(53c)
536
532b
535
532
532a
533a
531b
531
53a

FIG.4

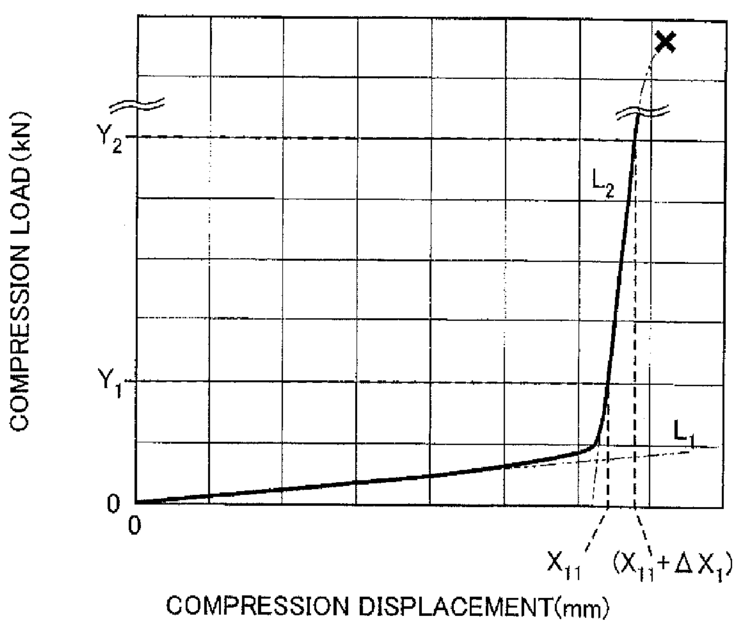

COMPRESSION LOAD (kN)
Y2
Y1
0
0
L2
L1
X11
(X11+ΔX1)
COMPRESSION DISPLACEMENT(mm)

FIG.5A

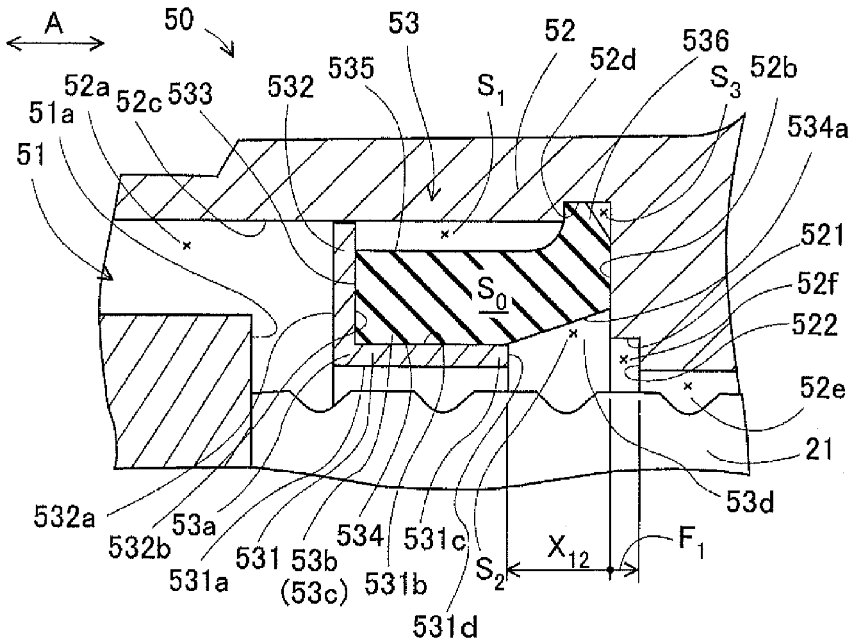
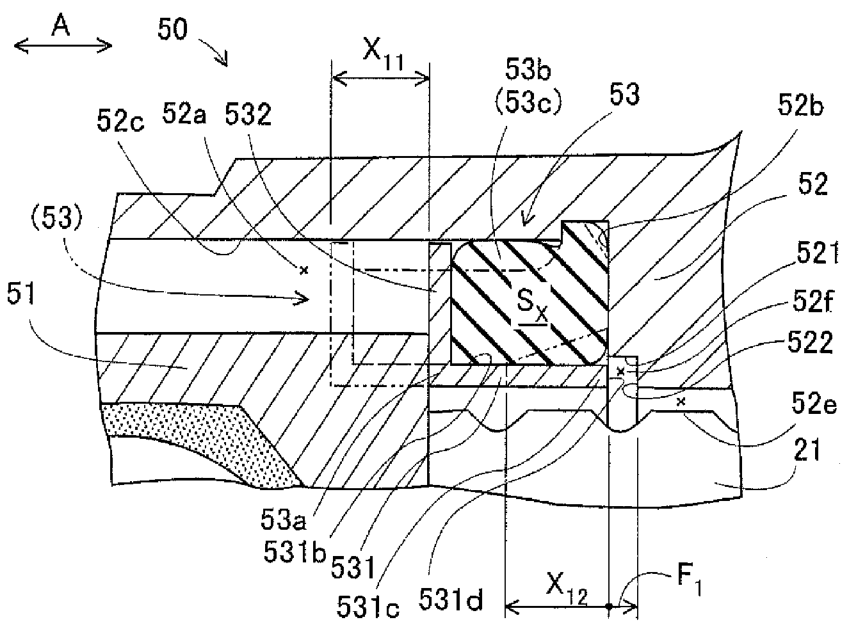

A
50
53
52
536
52d
S1
S3
52b
535
532
533
52c
52a
51a
51
534a
S0
521
52f
522
52e
21
53d
532a
532b
53a
531a
531
53b
(53c)
534
531b
531c
S2
531d
X12
F1

FIG.5B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50
X11
53b
(53c)
53
52c
52a
532
52b
52
(53)
51
Sx
521
52f
522
52e
21
53a
531b
531
531c
531d
X12
F1

FIG.5C

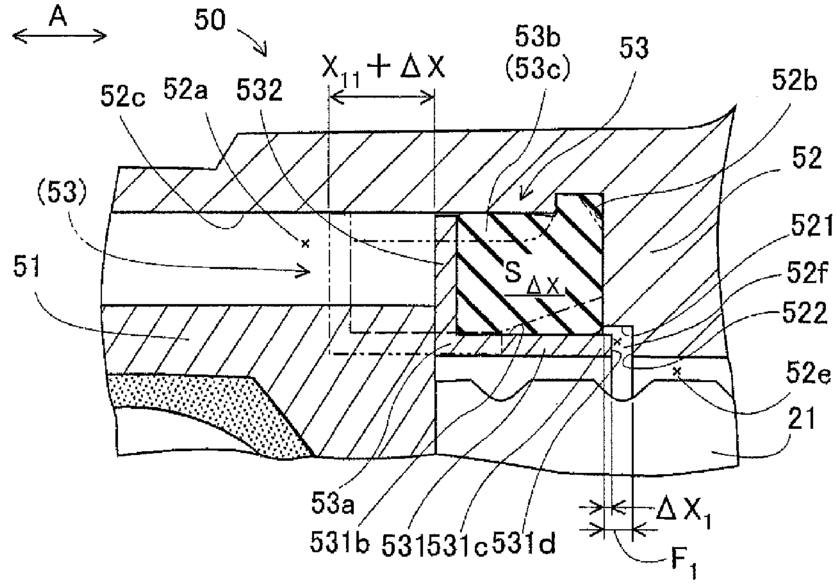
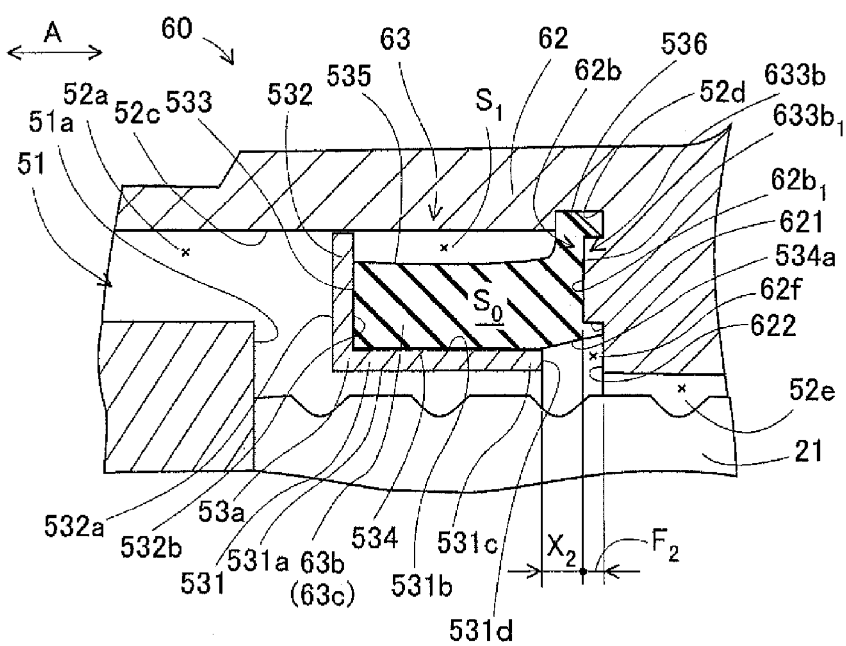

A
50
$X_{11}+\Delta X$
53b
(53c)
53
52c
52a
532
52b
52
(53)
521
51
$S_{\Delta X}$
52f
522
52e
21
53a
531b
531
531c
531d
ΔX_1
F_1

FIG.6A


A
60
63
62
536
62b
633b
S_1
52d
$633b_1$
52a
52c
533
532
535
51a
51
$62b_1$
621
534a
S_0
62f
622
52e
21
532a
532b
53a
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531a
63b
(63c)
534
531b
531c
531d
X_2
F_2

FIG.6B

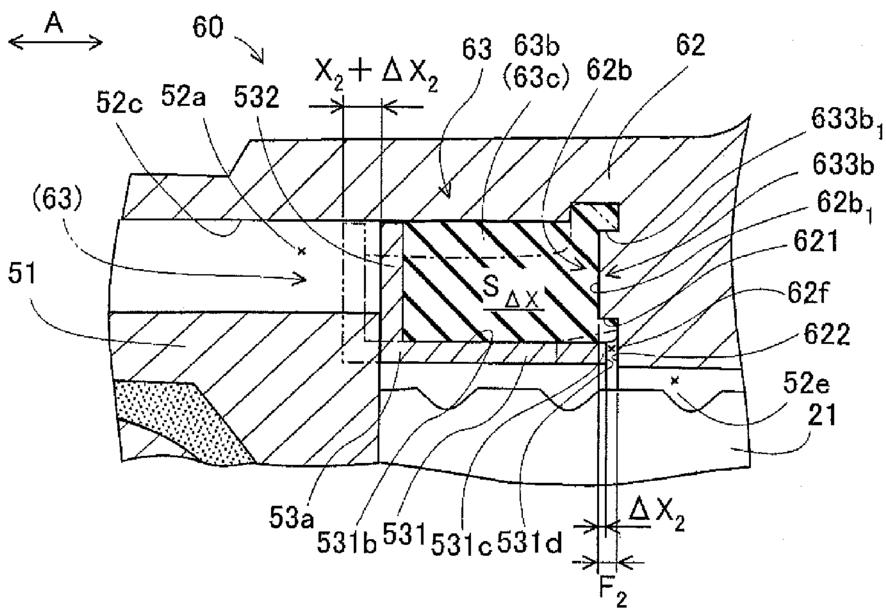
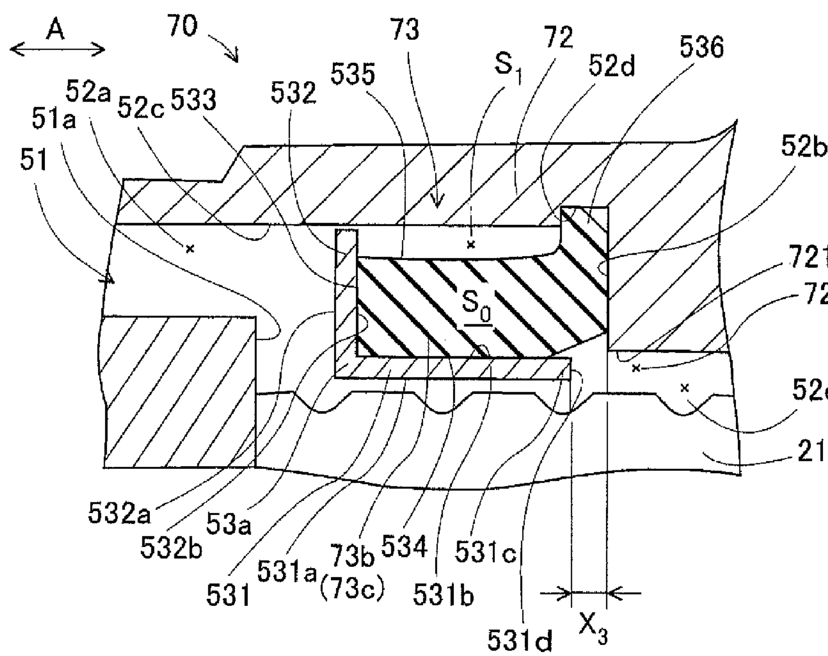

A
60
63
63b
(63c)
62b
62
$X_2+\Delta X_2$
52c
52a
532
$633b_1$
633b
$62b_1$
621
(63)
51
$S_{\Delta X}$
62f
622
52e
21
53a
531b
531
531c
531d
ΔX_2
F_2

FIG.7A


A
70
73
S_1
72
52d
536
52a
52c
533
532
535
51a
51
52b
S_0
721
72f
52e
21
532a
532b
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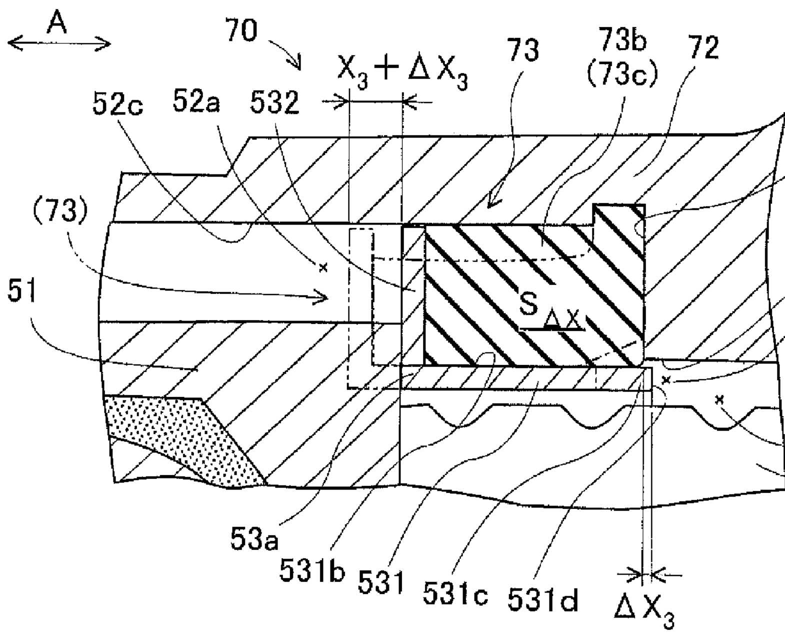
531
531a
73b
(73c)
534
531b
531c
531d
X_3

FIG.7B


A
70
$X_3+\Delta X_3$
73
73b
(73c)
72
52b
52c
52a
532
(73)
51
721
72f
$S_{\Delta X}$
52e
21
53a
531b
531
531c
531d
ΔX_3

DAMPER DEVICE AND STEERING DEVICE

INCORPORATION BY REFERENCE

This application is based on and claims priority under 35 U.S.C. 119 with respect to Japanese Application No. JP2015-208062 filed on Oct. 22, 2015, the entire content of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to a damper device and a steering device which uses the damper device.

Description of Related Art

A steering device used for a vehicle changes the direction of steered wheels (tires) by reciprocally moving a rack shaft in an axial direction which is connected to the steered wheels through tie-rods. The rack shaft is slidably accommodated in a housing. The rack shaft is structured such that the reciprocal movement range of the rack shaft is physically restricted upon reaching to the limit of a reciprocal movement range by the collision of the large diameter portion formed at the end of the rack shaft with the housing. In more detail, accompanied by the operation of the steering wheel by a driver of the vehicle, the force which moves the rack shaft in an axial direction (forward force) is inputted. Vice versa, for example, when the steered wheel rides onto a curbstone, an excessive force is inputted from the steered wheel towards the rack shaft. Such excessive force moves the rack shaft in an axial direction (reverse force). Accompanied by the input of the forward or reverse force, when the rack shaft is moved in an axial direction until it collides with the housing, a so-called "end abutting" occurs.

In a steering device, a damper device is provided at the end abutting portion to absorb or dampen the impact generated upon end abutting operation. As a damper device, a device has been known which includes a rack shaft with a large diameter portion, a housing through which the rack shaft is movably inserted in an axial direction, the housing restricting the axial movement of the large diameter portion of the rack shaft, and an impact absorbing member which is inserted on a shaft portion of the rack shaft and is disposed between the end surface of the large diameter portion and the housing in an axial direction.

The steering device according to the Patent Literature 1 includes an elastic body (impact absorbing member) disposed between the end member (large diameter portion) and the housing. The impact absorbing member absorbs the collision impact while receiving the impact through the large diameter portion when the large diameter portion collides with the housing. The impact absorbing member includes an end plate (impact receiving member) which receives the collision impact upon contacting with the large diameter portion. The impact receiving member is formed with a restricting portion which contacts with a predetermined portion of the housing. In the Patent Literature 2, an impact absorbing member (damping member) is disclosed, which has an annular plate shaped restricting portion (stopper member) similar to that disclosed in the Patent Literature 1. The damper device according to the Patent Literature 3 includes an impact absorbing member (dampening member) provided at the end portion of the large diameter portion (rack end) facing to the housing. In detail, an annular shaped impact absorbing member is provided on and projecting from the end surface of the large diameter portion. A recessed portion which functions as a "restricting portion" of the Patent Literatures 1 and 2 is provided at the restricting surface of the housing. By the contact between the large diameter portion and the restricting surface of the housing, the compression displacement of the impact absorbing member in an axial direction can be restricted in a predetermined range.

LIST OF RELATED ART

Patent Literature

[PATENT LITERATURE 1]: JP 2015-128981 A
[PATENT LITERATURE 2]: JP2015-63157 A
[PATENT LITERATURE 3]: JP2012-35713 A

DISCLOSURE OF INVENTION

Problems to be Solved by the Invention

However, the damper device according to the Patent Literatures 1 and 2, the structure that the restricting portion is in contact with a predetermined portion of the housing is a prerequisite. The impact absorbing member is displaced in an axial direction when a predetermined force is applied. The restricting portion stops the displacement of the impact absorbing member by the contact with the housing. Thus, the compression displacement of the elastic body of the impact absorbing member is restricted in a certain range and an advantageous effect that a durability of the elastic body is assured can be achieved. Normally, the restricting portion and the housing are formed by a metal material. Thus, when the collision force received by the impact absorbing member is excessively great, the restricting portion and the housing are momentarily brought into contact with each other with a large force and a collision impact of metal to metal is generated. The damper device in the Patent Literature 3, also may generate similar collision impact by the contact of the metal made large diameter portion and the restricting surface of the metal made housing.

For example, in a steering device, each of the components forming the steering device is designed to be durable against a collision impact upon input of the large reverse force generated for example upon riding onto a curbstone by absorbing the impact by the impact absorbing member. However, designing of the components considering a collision impact of larger reverse force which would not be generated practically is not achieved.

The present invention has been made considering the above issues and it is an object of the present invention to provide a damper device and a steering device which can sustain the functions of the device by surely suppressing a force of impact to be transmitted to each component of the device.

Means to Solve the Problems

The damper device according to the invention includes a shaft provided with a shaft portion and a large diameter portion, a housing formed in a cylindrical shape and through which the shaft is inserted for a slidable movement thereof in an axial direction relative to the housing, the housing being provided with a restricting surface facing toward an end surface side of the large diameter portion and an impact absorbing member inserted on the shaft portion and disposed between an end surface of the large diameter portion and the restricting surface in an axial direction. The impact absorbing member of the damper device includes an impact receiving member which is provided with a cylindrical portion facing to an inner peripheral surface of the housing and a flange portion extending from the cylindrical portion outwardly in a radial direction and facing to the restricting surface and being contactable with the large diameter portion and an elastic body provided in a space formed by the inner peripheral surface of the housing, the restricting surface, an outer peripheral surface of the cylindrical portion and the flange portion and formed by a rubber material or a synthetic resin material having a rubber-like elasticity. The housing of the damper device includes a relief portion defined by an area provided continuously inwardly in a radial direction of the restricting surface wherein an end portion of the cylindrical portion can be more advanced towards an opposite side to the large diameter portion than the restricting surface along in an axial direction.

When the large diameter portion does not apply an impact force on the flange portion, the elastic body is disposed having a gap relative to at least one of the inner peripheral surface of the housing and the outer peripheral surface of the cylindrical portion. When the large diameter portion applies the impact force on the flange portion, the elastic body is compressed by the restricting surface and the flange portion in an axial direction. Therefore, the elastic body is deformed to fill up the gap so that the inner peripheral surface of the housing, the restricting surface, the outer peripheral surface of the cylindrical portion and the flange portion are all brought into contact with the elastic body. Then the movement of the impact receiving member relative to the housing is restricted by the deformed elastic body, maintaining a non-contact state of the impact receiving member relative to the housing during an advancing movement of the end portion of the cylindrical portion into the relief portion.

The steering device according to the present invention includes the damper device according to the present invention. The steering device includes the shaft including a rack shaft connected to the steered wheels through tie rods and steers the steered wheels to be steered by reciprocating in an axial direction. The shaft is provided with the large diameter portion to which the tie rod are connected and the housing which accommodates the rack shaft therein.

According to the damper device or the steering device of the present invention, when the large diameter portion applies the impact force to the flange portion, the elastic body starts to be compressively deformed to reduce the gap and then is further compressively deformed to fill up the gap. By the contact of the elastic body with all four surfaces in vertical section, the rigidity of the elastic body is increased and the movement of the impact receiving member relative to the housing can be restricted. The housing is provided with the relief portion, into which the end portion of the cylindrical portion can be more advanced along in an axial direction from the restricting surface towards the opposite side to the large diameter portion. The end portion of the cylindrical portion of the impact receiving member is advanced into the relief portion. The escaping area for enabling the end portion of the cylindrical portion to advance therein when the large diameter portion applies the impact force to the flange portion is ensured by the relief portion to surely avoid the contact between the impact receiving member and the housing. The impact receiving member can surely maintain the non-contact state with the housing and each component of the device can be prevented from transmission of the impact force to improve the reliability of the device.

In this specification, the "elastic body" indicates any member formed by a raw material which expresses "rubber like elasticity" as defined in general and any member within this meaning should not be excluded. As such elastic body, a rubber material or a synthetic resin having a rubber like elasticity can be preferably used.

BRIEF DESCRIPTION OF THE ATTACHED DRAWINGS

Various aspects of this invention will become apparent to those skilled in the art from the following detailed description of the preferred embodiments, when read in light of the accompanying drawings, in which:

FIG. **1** is a conceptual view of the entire electric power steering device according to an embodiment of the invention;

FIG. **2** is a cross sectional view of the structure of the damper device according to the embodiment;

FIG. **3** is a partial perspective view of the impact absorbing member according to the embodiment;

FIG. **4** is a graph showing a relationship between the compression load and the displacement of the impact absorbing member;

FIG. **5**A is a cross sectional view of the state of the impact absorbing member before the end abutting;

FIG. **5**B is a cross sectional view of the state of the damper device when a normal impact force is applied to the impact absorbing member;

FIG. **5**C is a cross sectional view of the state of the damper device when an impact force is applied to the impact absorbing member under abnormal condition;

FIG. **6**A is a cross sectional view of the damper device before the end abutting according to a modified embodiment **1**;

FIG. **6**B is a cross sectional view of the damper device after the end abutting according to the modified embodiment **1**;

FIG. **7**A is a cross sectional view of the damper device before the end abutting according to a modified embodiment **2**; and

FIG. **7**B is a cross sectional view of the damper device after the end abutting according to the modified embodiment **2**;

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS OF THE INVENTION

Hereinafter, a damper device according to the present invention and a steering device according to the present invention in which the damper device of the present invention is used will be explained based on the concrete embodiments of the invention with reference to the attached drawings. In FIG. **1**, the steering device ST includes a steering mechanism **10**, a turning mechanism **20**, a steering assist mechanism **30**, a torque detecting device **40** and a damper device **50**.

1. Structure of Steering Device

As indicated in FIG. **1**, the steering mechanism **10** includes a steering wheel **11** and a steering shaft **12**. The steering wheel **11** is fixed to an end portion of the steering shaft **12**. The steering shaft **12** transmits a steering torque applied to the steering wheel **11** for turning the steered wheels **26**,**26** to be steered. The steering shaft **12** is formed by connecting a columnar shaft **13**, an intermediate shaft **14** and a pinion shaft **15**. The pinion shaft **15** includes an input shaft **15***a*, an output shaft **15***b* and a torsion bar **15***c*. An input side portion of the input shaft **15***a* is connected to an output side portion of the intermediate shaft **14**. A pinion gear **15***d* is formed at an output side portion of the output shaft **15***b*.

The turning mechanism **20** includes a rack shaft **21** and a housing **22** formed substantially of a cylindrical shape. The rack shaft **21** is accommodated in the housing and supported thereby for reciprocal movement in a straight line along in an A-axis direction. The housing **22** includes a first housing **22***a*, and a second housing **22***b* fixed to the first housing **22***a* at the left side as viewed in FIG. **1** along in the A-axis direction.

The pinion shaft **15** is rotatably supported in the first housing **22***a*. The rack shaft **21** is provided with a rack gear **21***a* and the rack gear **21***a* and the pinion gear **15***d* are mutually in mesh with each other to form a rack and pinion mechanism **23**. The rack and pinion mechanism **23** is accommodated in the first housing **22***a*.

The rack shaft **21** includes a pair of large diameter portions **51**, **51** at both ends of a shaft portion **211**. The pair of large diameter portions **51**, **51** is formed by extending the diameter of both ends of the shaft portion **211** of the rack shaft **21**. A pair of ball studs **27**, **27** is accommodated in the pair of large diameter portions **51**, **51** to form a ball joint. A pair of tie rods **24**, **24** is connected to each end portion of the ball studs **27**, **27** and each tip end of the tie rods **24**, **24** is connected to a knuckle (not shown) to which the steered wheels **26**, **26** to be steered are assembled. Thus, when the steering wheel **11** is steered, the steering torque is transmitted to the steering shaft **12** and the pinion shaft **15** is rotated. The rotation of the pinion shaft **15** is converted into the straight line reciprocal movement of the rack shaft **21** by the engagement of the pinion gear **15***d* and the rack gear **21***a*. This reciprocal movement is transmitted to the knuckles via the tie rods **24**, **24**. Thus, the steered wheels **26**, **26** to be steered are turned to change the running direction of the vehicle. It is noted here that the numeral **25** indicates a boots for keeping the accommodation space of the turning mechanism **20** including the inside of the housing **22** to be in air-tight condition.

A pair of impact absorbing members **53**, **53**, which will be explained later in detail, is provided at both ends of the housing **22**. The pair of impact absorbing members **53**, **53** is accommodated in a pair of large diameter portion housings **52**, **52** for the large diameter portions, one formed at one end side portion of the first housing **22***a* and the other formed at the other side end portion of the second housing **22***b* and is attached to a pair of restricting surfaces **52***b*, **52***b* (See FIG. **2**). The impact absorbing members **53**, **53** are disposed between the large diameter portions **51**, **51** and the restricting surfaces **52***b*, **52***b* facing to the large diameter portions **51**, **51** which are provided for stopping the straight line movement of the rack shaft **21**. When the rack shaft **21** moves along in the A-axis direction and the steered wheels **26**, **26** to be steered reach the maximum steerable angle, an "end butting" where the large diameter portion **51** collides with the impact absorbing member **53** occurs. The impact of the collision is absorbed by the impact absorbing member **53**.

The steering assist mechanism **30** is a mechanism which applies a steering assist force to the steering mechanism **10** by a motor M, as a driving source, which is controlled based on the output of the torque detecting device **40**. The steering assist mechanism **30** includes an electric equipment MCU (Motor Control Unit), a ball screw mechanism **33** and a driving force transmitting mechanism **35**. It is noted here that the steering device ST of this embodiment is structured as a so-called rack parallel type electric power steering device.

The electric equipment MCU accommodated in a housing **31** includes the motor M and a control portion ECU for driving the motor M. A drive pulley of the driving force transmitting mechanism **35** is attached to an output shaft of the motor M. The ball screw mechanism **33** includes a ball screw portion **21***b* and a ball screw nut **33***a* (corresponding to nut of the invention). The ball screw nut **33***a* is engaged with the ball screw portion **21***b* of the rack shaft **21** via a plurality of balls. The driving force transmitting mechanism **35** includes the drive pulley, a toothed belt and a driven pulley and transmits the rotation driving force generated by the motor M between the drive pulley and the driven pulley via the toothed belt.

According to the structure explained above, the steering assist mechanism **30** drives the motor M in response to the rotation operation of the steering wheel **11** to rotate the output shaft. By the rotation of the output shaft, the rotation torque is transmitted to the drive pulley to rotate the drive pulley. The rotation of the drive pulley is transmitted to the driven pulley via the toothed belt. By the rotation of the driven pulley, the ball screw nut **33***a*, which is formed integrally with the driven pulley, is rotated. By the rotation of the ball screw nut **33***a*, the steering assist force in the axial direction is transmitted to the rack shaft **21** via the balls.

The torque detecting device **40** is fixed to an attachment opening portion **22***e* positioned surrounding the pinion shaft **15**. The torque detecting device **40** detects a torsion amount of the torsion bar **15***c* and outputs signals to the control portion ECU in response to the torsion amount. It is noted that the torsion bar **15***c* referred here is a member having a torsional characteristics and is twisted in response to a difference in torque between an input shaft **15***a* and an output shaft **15***b*. The control portion ECU controls the output of the motor M by deciding the steering assist torque based on the output signal from the torque detecting device **40**.

2. Damper Device

The damper device **50** will be explained with reference to FIG. **2** of the attached drawings. Accompanied by a forward input inputted in response to the steering operation by the driver of the vehicle, or accompanied by a reverse input inputted from an exterior of the vehicle via the steered wheel **26** to be steered, the large diameter portion **51** moves along in the A-axis direction and the impact absorbing member **53** of the damper device **50** absorbs impact to be generated when a collision of the large diameter portions **51** with the restricting surface **52***b* of the large diameter portion housing **52** is about to occur. The damper device **50** includes the rack shaft **21**, the large diameter portion housing **52** and the impact absorbing member **53**. It is noted that the damper device **50** according to this embodiment is provided at two portions, at right and left sides, relative to the steering device ST in the A-axis direction. It is noted further that the right side as viewed in FIG. **1** is referred to as "one side" and the left side in FIG. **1** is referred to as "the other side". Unless otherwise defined, the damper device **50** will be explained based on "the other side" damper device neighboring the steering assist mechanism **30** in FIG. **1**.

As shown in FIG. **1**, the rack shaft **21** of the damper device **50** includes the pair of large diameter portions **51**, **51** and the shaft portion **211**. Each of the large diameter portions **51**, **51** is provided at each end portion of the rack shaft **21**.

The shaft portion **211** is provided between the pair of large diameter portions **51**, **51**. The shaft portion **211** includes the ball screw portion **21***b* and the rack gear **21***a*. The large diameter portion **51** of the other side as shown in FIG. **2**, is connected to a shaft portion **271** of the ball stud **27**.

An end portion **511** positioned at the "one side" of the large diameter portion **51** is connected to the shaft portion **211**. The diameter of the end portion **511** is formed to be larger than the diameter of the shaft portion **211**. A male screw portion **51***b* is formed at the end portion **511** extending from the end portion **511** to the one side in the A-axis direction. At the central portion of the end surface **212** of the shaft portion **211** of the rack shaft **21** is provided a female screw portion **213** which opens to the other side in the A-axis direction and engages with the male screw portion **51***b*.

The contact end surface **51***a* is formed at the root portion of the male screw portion **51***b* and extends outwardly in a radial direction from the root portion of the male screw portion **51***b*. According to this embodiment, the contact end surface **51***a* is the most end surface **212** of the rack shaft **21**. In other words, the contact end surface **51***a* serves as a so-called rack end. According to this structure, when the rack shaft **21** reciprocally moves in a straight line, the contact end surface **51***a* engages with the restricting surface **52***b* via the impact absorbing member **53** and serves as a stopper for restricting the reciprocal movement of the rack shaft **21**.

The large diameter portion **51** includes a socket portion **51***c*, which accommodates the ball stud **27** therein, at the end portion **512** positioned at the other side as viewed in FIG. **2**. A tip end of the ball stud **27** at the one side is formed of a spherical shape which is indicated as a ball portion **27***b*. The socket portion **51***c* rotatably accommodates the tip end of the ball portion **27***b* through a damper material **27***c*. In FIG. **2**, the shaft portion **271** is formed at the other side of the ball stud **27**. The end portion of the other side of the shaft portion **271** and the knuckle are connected through the tie rod **24**. Thus, the large diameter portion **51** connects the ball stud **27** at the end portion **512** and is connected to the steered wheel **26** to be steered via the ball stud **27**, the tie rod **24** and the knuckle (not shown). (See FIG. **1**). When the rack shaft **21** moves in a straight line along in the A-axis direction, the tie rod **24** is swung about the ball portion **27***b* inserted into the large diameter portion **51**. Then, the steered wheel **26** to be steered can be turned until the contact end surface **51***a* is engaged with the impact absorbing member **53** which is attached to the restricting surface **52***b*.

Each of the pair of large diameter portion housings **52**,**52** forms a portion of the housing **22** and one of the large diameter portion housings **52**,**52** forms an end portion at the one side of the first housing **22***a* and the other forms an end portion of the other side of the second housing **22***b*. The pair of the large diameter portion housings **52**,**52** is formed of a substantially bottomed cylindrical shape and each is arranged in the A-axis direction with an opening open to respective steered wheels **26**, **26** side. The rack shaft **21** is inserted into the pair of large diameter portion housings **52**, **52** (housing **22**) and is relatively movable in the A-axis direction. Each large diameter portion housing **52** includes a shaft accommodating portion **52***e*, a large diameter portion accommodating portion **52***a*, the restricting surface **52***b*, the inner peripheral surface **52***c* and the relief portion **52***f*.

As shown in FIG. **2**, a shaft accommodating portion **52***e* and a large diameter portion accommodating portion **52***a* are cylindrical spaces respectively having substantially constant inner diameters and are formed co-axially with an A-axis. The shaft accommodating portion **52***e* accommodates the shaft portion **211** of the rack shaft **21**, under the state that the shaft portion **211** is inserted into the shaft accommodating portion **52***e*. The inner diameter of the large diameter portion accommodating portion **52***a* is set to be larger than the inner diameter of the shaft accommodating portion **52***e* and is in communication therewith. The large diameter portion accommodating portion **52***a* is open to the side where the steered wheel **26** to be steered is positioned for accommodating the shaft portion **211** and the large diameter portion **51** therein.

The restricting surface **52***b* is a flat bottom surface side forming the bottom wall of the large diameter portion accommodating portion **52***a* and is formed facing toward the contact end surface **51***a* of the large diameter portion **51**. The restricting surface **52***b* is brought into contact with the contact end surface **51***a*, which is the most end surface (rack end), through the impact absorbing member **53** to thereby restrict physically the range of movement of the rack shaft **21** in a straight line.

An inner peripheral surface **52***c* is an inner peripheral surface of the large diameter portion accommodating portion **52***a* and an end portion of the inner peripheral surface **52***c* having a common surface with the restricting surface **52***b* at the restricting surface **52***b* side is provided with an annular groove **52***d* which diameter is enlarged towards outwardly in a radial direction from the inner peripheral surface **52***c*. The annular groove **52***d* engages with an annular projection portion **536** to mount the impact absorbing member **53** on to the restricting surface **52***b*.

The relief portion **52***f* is a recessed annular space area provided continuously with a step at the inner peripheral surface and the restricting surface **52***b* of the shaft accommodating portion **52***e* at the other side inwardly in a radial direction. The relief portion **52***f* is formed so that the end portion **531***c* of the cylindrical portion **531** can be inserted into the opposite side of the large diameter portion than the restriction surface **52***b* in the A-axis direction. In other words, the relief portion **52***f* allows the end portion **531***c* of the cylindrical portion **531** to escape into the space of the relief portion **52***f* and maintains the non-contact state between the impact receiving member **53***a* and the large diameter portion housing **52**. As shown in FIG. **5**A, the relief portion **52***f* is formed by an inner peripheral surface **521** which is larger in diameter than the outer peripheral surface **531***b* of the cylindrical portion **531** and a bottom surface **522** which faces to the end surface **531***d* of the cylindrical portion **531**. In more detail, the inner diameter of the inner peripheral surface **521** is formed to be larger than the outer diameter of the outer peripheral surface **531***b* of the cylindrical portion **531** by one (1) mm. Further, the depth (distance) from the restriction surface **52***b* to the bottom surface **522** is formed to be F_1 mm.

3. Impact Absorbing Member

The impact absorbing member **53** is a member for absorbing a collision impact upon the "end abutting". The impact absorbing member **53** is inserted into the shaft portion **211** and is disposed between the contact end surface **51***a* of the large diameter portion **51** and the restricting surface **52***b* of the large diameter portion housing **52** in the A-axis direction. The impact absorbing member **53** is formed by the impact receiving member **53***a* which is made by a cylindrical steel plate having a flange portion **532** and the elastic body **53***b* made from a rubber material and having approximately a cylindrical shape. The impact absorbing member **53** is mounted on the restricting surface **52***b* of the large diameter portion housing **52** so that an end surface **532***a* to be contacted of the impact receiving member **53***a* faces to the contact end surface **51***a* of the large diameter portion **51**.

In more detail, as shown in FIG. **3**, the impact absorbing member **53** is approximately of an annular cylindrical shape in general with the cylindrical portion **531** of the impact receiving member **53***a* being inserted into a through-hole of the elastic body **53***b*. The impact absorbing member **53** is formed by integrally adhere the end surface **533***a* of the elastic body **53***b* at the other side to the impact receiving member **53***a*. An opening **53***d* is provided at the inner peripheral surface side of the impact absorbing member **53**. By this opening **53***d*, the impact receiving member **53***a* opens by a clearance X_{12} at the end portion at the one side, (See FIG. **2** and FIG. **5**A). Then, the one side end portion of the inner peripheral surface **534** of the elastic body **53***b* under non-deformed state is exposed outside from the opening **53***d*.

The impact receiving member **53***a* includes the cylindrical portion **531** and the flange portion **532**. The cylindrical portion **531** is positioned to face to the inner peripheral surface **52***c* of the large diameter portion housing **52** and the flange portion **532** extends outwardly in a radial direction from the cylindrical portion **531** and faces to the restricting surface **52***b*. Further, the flange portion **532** is formed to be contactable with the large diameter portion **51**. In more detail, the cross section as viewed in the A-axis direction of the impact receiving member **53***a* is of an L-shape. One side of the L-shape of the cylindrical portion **531** is indicated as a horizontal side in the A-axis direction and the other side of the L-shape is indicated as a vertical side which crosses the A-axis direction. When the impact receiving member **53***a* receives an impact force at the flange portion **532** caused by a contact or a collision from the contact end surface **51***a* of the large diameter portion **51**, the impact receiving member **53***a* applies a compression force on the elastic body **53***b* to transmit the impact thereto and absorbs the impact thereby.

The cylindrical portion **531** is formed of approximately a straight cylindrical shape. The through-hole of the impact absorbing member **53** is provided at the inner peripheral surface **531***a* of the cylindrical portion **531** for inserting the shaft portion **211** therethrough, under the cylindrical portion **531** being assembled to the large diameter portion housing **52**. The size of the outer diameter of the inner peripheral surface **531***b* of the cylindrical portion **531** is set so that the inner peripheral surface **534** of the elastic body **53***b* can be loosely inserted therein. The entire length of the cylindrical portion **531** in the A-axis direction is set depending on the later described compression displacement X_{11} of the impact absorbing member **53**. As shown in FIGS. **5**A and **5**B, the entire length of the cylindrical portion **531** is set so that the axial clearance X_{12} in the A-axis direction between the end surface **531***d* of the cylindrical portion **531** under non-deformed state and the restriction surface **52***b* becomes approximately the same with the compression displacement X_{11}. The cylindrical portion **531** is used for restricting the direction of the compression displacement of the inner peripheral surface **534** of the elastic body **53***b* to be along in the A-axis direction and further, the cylindrical portion **531** is also used for preventing the elastic body **53***b* from deforming inwardly in a radial direction to protrude beyond the cylindrical portion **531**.

The flange portion **532** is formed of an annular plate shape with a constant thickness. The flange portion **532** extends from the cylindrical portion **531** outwardly in a radial direction. The outer diameter of the flange portion **532** is set to be slightly smaller than the inner diameter of the inner peripheral surface **52***c* of the large diameter portion housing **52** (set to have a clearance of about 0.15 to 0.6 mm therebetween). The other side end surface **533***a* of the elastic body **53***b* is assembled to the rear surface **532***b* of the end surface **532***a* to be contacted, which is the annular end surface of the flange portion **532** at the other side. The end surface **532***a* to be contacted of the flange portion **532** directly receives an impact force generated by a contact or a collision of the end surface **532***a* to be contacted with the contact end surface **51***a* of the large diameter portion **51** and the impact received is transmitted to and absorbed by the elastic body **53***b*.

Next, the elastic body **53***b* will be explained hereinafter. It is noted here that unless otherwise defined, the explanation will be made for the elastic body under non-deformed state. The collision impact that the impact receiving member **53***a* receives upon a direct contact between the impact receiving member **53***a* and the large diameter portion **51** is transmitted to the elastic body **53***b* which absorbs the impact by being deformed within the predetermined space. The elastic body **53***b* is disposed in an initially set space S_0 which is formed by the inner peripheral surface **52***c* of the large diameter portion housing **52**, the restricting surface **52***b*, the outer peripheral surface **531***b* of the cylindrical portion **531** and the flange portion **532**.

In more detail, the elastic body **53***b* has a shape in general wherein a flange shaped annular projection portion **536** is provided at an approximately straight cylindrical shaped main body portion **53***c* at the one side end portion in the A-axis direction. The annular projection portion **536** projects outwardly in a radial direction from the main body portion **53***c*. The inner diameter of the main body portion **53***c* is set to be slightly larger than the outer diameter of the outer peripheral surface **531***b* of the cylindrical portion **531** and is loosely inserted into the outer peripheral surface **531***b*. The outer diameter of the main body portion **53***c* is set to be smaller than the outer diameter of the flange portion **532**. A clearance S_1 with a predetermined volume is formed between the main body portion **53***c* and the inner peripheral surface **52***c* under the main body portion **53***c* being assembled to the large diameter portion housing **52**. The elastic body **53***b* is disposed within the initially set space S_0 by engaging the annular projection portion **536** with the annular groove **52***d* provided at the restricting surface **52***b* and projecting outwardly in a radial direction from the inner peripheral surface **52***c*.

An enlarged diameter portion **534***a* is provided at a corner portion of the inner peripheral surface **534** of the elastic body **53***b* where the restricting surface **52***b* is positioned. The diameter of the enlarged diameter portion **534***a* is enlarged towards the restricting surface **52***b*. The enlarged diameter portion **534***a* is formed with an inclination wherein the diameter thereof is enlarged from the position of the end portion **531***c* of the cylindrical portion **531** towards the restricting surface **52***b* in the A-axis direction. The corner portion of the inner peripheral surface **534** facing the opening **53***d* is properly inclined with an angle which can suitably separate from the outer peripheral surface **531***b* of the cylindrical portion **531** upon the compressive deformation. Thus, when the elastic body **53***b* is deformed by compression, the inner peripheral surface **534** (enlarged diameter portion **534***a*) at the opening **53***d* would not be bitten in the end portion **531***c* of the cylindrical portion **531**.

An annular projection portion **536** is provided at the corner portion of the outer peripheral surface **535** of the elastic body **53***b* where the restricting surface **52***b* is positioned. The projection portion **536** projects from the main body portion **53***c* outwardly in a radial direction. The annular projection portion **536** is engaged in the annular groove **52***d* which is rectangular shape in vertical cross section of the large diameter portion housing **52** and assembles the restricting surface **52***b* thereon. As shown in FIG. **5**A, one side end surface of the annular projection portion **536** is inclined so that the diameter thereof becomes reduced towards the restricting surface **52***b*. Thus, a triangular clearance S_3 between the annular projection portion **536** and the annular groove **52***d* in vertical cross section under the state that the projection portion **536** is engaged in the groove **52***d*.

Each end surface **533***a*, **533***b* of the other side and the one side of the elastic body **53***b* is formed to be of a flat shape (See FIG. **3**). The end surface **533***a* of the other side is adhered to the rear surface **532***b* of the flange portion **532**. On the other hand, the inner peripheral surface **534** of the elastic body **53***b* is not adhered to the outer peripheral surface **531***b* of the cylindrical portion **531**. Adhesion area is formed at the entire surface of the end surface **533***a* of the other side of the elastic body **53***b* in order to ensure the maximum adhesive area. When a rubber material is used for the elastic body, a predetermined adhesive agent is applied on the rear surface **532***b* of the flange portion **532** and after the un-vulcanized rubber is injected towards the rear surface **532***b* exposed in the metal mold, the flange portion **532** is adhered to the elastic body **53***b* by vulcanization.

The material of the elastic body according to the invention is not limited and any material may be used as long as such material is formed to express a rubber like elasticity. For example, such as a crosslinked rubber, a thermoplastic or thermosetting synthetic resin system elastomer or the like can be used for forming the elastic body. As the crosslinked rubber, a diene based rubber, such as, natural rubber, butadiene rubber, isoprene rubber, chloroprene rubber, styrene-butadiene rubber, acrylonitrile-butadiene rubber (hereinafter referred to also as "NBR"), etc. and a rubber to which a hydrogen is added to an unsaturated portion thereof or the like, as the thermosetting synthetic resin system elastomer, an olefin system rubber such as ethylene-propylene rubber, butylene rubber, acryl rubber, urethane rubber, silicone rubber, fluoro rubber, etc., and as the thermoplastic synthetic resin system elastomer, an elastomer such as styrene system, olefin system, polyester system, polyurethane system, polyamide system, vinyl chloride or the like are exampled. According to the embodiment of the invention, as the material for the elastic body **53***b* used in the impact absorbing member **53** to be installed in the large diameter portion housing **52** of the steering device ST, considering the issues of heat-resistance, cold resistance and weatherability performance, NBR, chloroprene rubber, butyl rubber, ethylene-propylene rubber, etc., may be suitably applied, and further, considering the oil resistance, NBR or chloroprene rubber having polar group may be suitably applied.

4. Relative Movement Restriction by Elastic Body

Next, the operation of the steering device ST equipped with the damper device **50** according to the embodiment will be explained hereinafter. The steering device ST can be durable against an excessive impact force which is less likely to be generated in practical use. It is noted here that regarding to the expression "excessive impact force", the expression "under abnormal state" will be used properly and regarding to the impact force which would normally be assumed to be generated, the expression "under normal state" will be used to differentiate the state from the "abnormal state". The explanation will be made with reference to FIGS. **4**, **5**A through **5**C.

FIG. **5**A is a view of the impact absorbing member **53** under non-deformed state being disposed in the large diameter portion housing **52**. As shown in FIG. **2**, the main body portion **53***c* of the elastic body **53***b* is disposed in the initially set space S_0 formed by the inner peripheral surface **52***c* of the large diameter portion housing **52**, the restricting surface **52***b* of the large diameter portion housing **52**, the outer peripheral surface **531***b* and the flange portion **532**. The elastic body **53***b*, the cylindrical portion **531** and the inner peripheral surface **52***c* are co-axially arranged relative to the center axis line of the rack shaft **21**. (See FIG. **2**). The restricting surface **52***b* of the large diameter portion housing **52** and the flange portion **532** are respectively arranged in a vertical direction relative to the center axis line of the rack shaft **21** and are positioned in parallel with each other.

When the large diameter portion **51** does not apply the impact force on the flange portion **532**, the elastic body **53***b* is disposed in the large diameter portion housing **52** with the clearance S_1 from the inner peripheral surface **52***c* thereof. Further, the elastic body **53***b* is disposed with a clearance S_2 on an outer peripheral surface of the cylindrical portion **531**, which is an imaginal outer peripheral surface formed assuming that the end surface **531***d* of the cylindrical portion **531** extends to the position of the restricting surface **52***b* in the A-axis direction. Further, the elastic body **53***b* is disposed between the annular projection portion **536** and the annular groove **52***d* with a clearance S_3. The volume of the initially set space S_0 is formed to be the value approximately the same with the volume which is the sum of the volume Vr of the elastic body **53***b* and the total volume Vs of each gap S_1 through S_3. The end surface **531***d* of the cylindrical portion **531** is arranged to have the clearance X_{12} with the restricting surface **52***b* in the A-axis direction. The clearance X_{12} corresponds to the compression displacement X_{11} in the A-axis direction upon receipt of the impact force under the normal state. (See FIG. **5**B). The end surface **531***d* faces to the bottom surface **522** of the relief portion **52***f* with a clearance corresponding to the depth F_1 in the opposite side of the large diameter portion in addition to the clearance X_{12}.

The impact absorbing member **53** has a relationship between the compression load and the compression displacement as shown in a graph shown in FIG. **4**, when the elastic body **53***b* is formed by a predetermined NBR material. The elastic body **53***b* exhibits the linear rubber like elasticity complied with the characteristic of the line L**1** within a predetermined range of the compression load, but when the compression load becomes large beyond the predetermined range, the elastic body **53***b* exhibits the elasticity complied with the characteristic of the line L**2** and the rigidity of the elastic body **53***b* becomes high to be cured. When the large diameter portion **51** applies the impact force on the flange portion **532**, the elastic body **53***b* is pressed in the A-axis direction by the restricting surface **52***b* and the flange portion **532** and deformed by compression to fill the space occupied by the gaps S_1 through S_3. At the initial stage of the compressive deformation where the clearance X_{12} between the end surface **531***d* of the cylindrical portion **531** and the restricting surface **52***b* is gradually shortened, the collision impact is absorbed by the rubber like elasticity complied with the characteristic of the line L**1**.

FIG. **5**B illustrates the state where the impact absorbing member **53** receives the impact force which compressively deforms the elastic body **53***b* of the impact absorbing member **53** so that the inside of the compression space Sx is filed with the elastic body **53***b*. In detail, this state indicates an imaginary case where an impact force which is larger than the impact force at the time of forward inputting and which is about the same to the impact force generated upon the vehicle running over the curbstone is reversely inputted. The impact force of this case approximately corresponds to the compression load **Y1** [k N]. (See FIG. **4**). The elastic body **53***b* is compressively deformed so that the elastic body **53***b* is brought into contact with all of the inner peripheral surface **52***c* of the large diameter portion housing **52**, the restricting surface **52***b* of the large diameter portion housing **52**, the outer peripheral surface **531***b* of the cylindrical portion **531** and the flange portion **532** after the compression displacement X_{11} in the A-axis direction. At this time, the position of the end surface **531***d* of the cylindrical portion **531** is approximately the same position to the restricting surface **52***b* in the A-axis direction. This position in the A-axis direction indicates the position of the end surface **531***d* immediately before entering into the relief portion **52***f*. Under this state, the end surface **531***d* and the bottom surface **522** are separately positioned in the A-axis direction with each other having a clearance corresponding to the depth F_1 therebetween. The elastic body **53***b* is substantially filled in the compression space Sx. The volume of the elastic body **53***b* after compressive deformation is the same as the volume before the compressive deformation due to the non-compressive fluid characteristic of the elastic body **53***b* having a rubber like elasticity. Therefore, the volume of the compression space Sx is approximately the same with the volume Vr of the elastic body **53***b*. The volume change (S_0−Sx) between before and after the compressive deformation is considered to be approximately the same with the total volume Vs of the gaps S_1 through S_3.

The elastic body **53***b* is disposed in the compression space Sx formed by the large diameter portion housing **52** and the impact receiving member **53***a* and sealed therein with a sealing contact therewith. The compression space Sx has a slight gap between the inner peripheral surface **521** of the relief portion **52***f* and the outer peripheral surface **531***b* of the cylindrical portion **531**. However, basically the space does not have a passage through which the elastic body **53***b* overflows outside from the compression space Sx. Accordingly, the elastic body **53***b* cannot be compressively deformed further within the compression space Sx which volume is substantially the volume Vr and is saturated in volume. Accordingly, the elastic body keeps continuing the disposed state between the flange portion **532** and the restricting surface **52***b* to thereby preventing the impact receiving member **53***a* from displacing in the opposite side of the large diameter portion in the A-axis direction. As shown in FIG. **4**, the performance of the rubber characteristic of the elastic body **53***b* which is compressively displaced with the compression displacement X_1 (mm) receiving the compression load **Y1** [k N] is indicated as the state where the performance line has just changed from the line **L1** to **L2**. Under this state, the rigidity of the elastic body **53***b* has been increased. Thus, the impact absorbing member **53** which has compressively deformed with the compression displacement X_{11} (mm) in the A-axis direction is difficult to be further displaced even an impact force larger than the compression load **Y1** [k N] is applied. When receiving an impact force at normal state applied upon the vehicle running over the curbstone which not often occurs but practically may occur, the end surface **531***d* of the cylindrical portion **531** and the bottom surface **522** of the relief portion **521** are separated with each other having a space corresponding to the depth F_1 and the non-contact state between the metal made impact receiving member **53***a* and the metal made large diameter portion housing **52** can be surely maintained. Thus, the impact transmitting restriction of the steering device under normal state can be effectively performed.

FIG. **5**C illustrates the state that the impact absorbing member **53** receives the impact force under abnormal state. In other words, FIG. **5**C shows the state that the impact absorbing member **53** receives an excessive impact force. Under this state, the compression load **Y2** [k N] (three times bigger than the load **Y1**) is assumed to be applied. (See FIG. **4**). As illustrated in the drawing, the elastic body **53***b* shown in FIG. **5**C is further compressively displaced towards the opposite side of the large diameter portion in the A-axis direction by the value ΔX_1 compared to the case where the impact force applied under the normal state as explained above. Accompanied by the compressive deformation of the elastic body **53***b*, the impact receiving member **53***a* is also displaced in the A-axis direction by the value ($X_{11}+\Delta X_1$) from the position at non-deformed state. The elastic body **53***b* within the compression space SΔx expands in the space approaching closer to the 100% filling ratio and finally the volume thereof is saturated such that the compressive deformation cannot be possible anymore. The elastic body **53***b* keeps continuing the disposed state between the flange portion **532** and the restricting surface **52***b*. On the other hand, the end portion **531***c* of the cylindrical portion **531** is displaced towards the opposite side of the large diameter portion further than the restricting surface **52***b* along in the A-axis direction so that the end surface **531***d* is advanced into the relief portion **52***f* by the distance ΔX_1. As explained, under the state that the performance of the rubber characteristic of the elastic body **53***b* complies with the characteristic of the line **L2** under the displaced state by the compression displacement X_{11} (mm). The rigidity of the elastic body **53***b* becomes suddenly great. The displacement of the impact receiving member **53** stops when the displacement value becomes ΔX_1, even the compression load becomes increased up to the value **Y2** [k N]. This displaced distance ΔX_1 corresponds to the value of one sixteenth (1/16) of the value X_{11}. By setting the depth F_1 up to the bottom surface **522** of the relief portion **52***f* keeping sufficient allowance, based on the value ΔX_1 as a reference value, the non-contact state between the impact receiving member **53***a* and the large diameter portion housing **52** can be surely realized even when the impact force under the abnormal state is applied.

When receiving an excessive impact under the abnormal state from the exterior, the impact force transmitted to the damper device **50** depends on the vehicle speed at the time and the vehicle weight. According to the example above, it is assumed that the impact load of **Y2** [k N] is reversely inputted. However, it is possible to set the impact load that is two or three times greater than the impact load of **Y2** [k N]. Based on the rubber characteristic of the elastic body **53***b* shown in FIG. **4**, the reference value ΔX, (mm) for the depth F_1 to the bottom surface **522** is obtained similarly. Based on the reference value ΔX_1 (mm), the depth F_1 can be properly obtained to realize the non-contact state between the impact receiving member **53***a* and the large diameter portion housing **52**. Even when the impact force under the abnormal state is applied, the impact transmitting restriction effect on the drive force transmitting mechanism **35** associated with the steering assist mechanism **30** arranged adjacent to the damper device **50** can be achieved. Under such state, the steering function such as steering wheel operation or the like can be maintained and any choices of countermeasure when necessary can be assured. It is noted that in FIG. **4** the bold character "X" in the graph shows the imaginary limit point where the elastic body may be destroyed. The impact is absorbed to the maximum limit and the transmission of the impact force to each component of the steering device ST can be suppressed from the time when the impact absorbing member **53** receives the impact force from the large diameter portion **51** and compressed until it is destroyed. As a result, providing for a case where an excessive impact force is applied under unexpected circumstances. The function of the steering device ST can be maintained.

5. Modified Embodiments

Next, the damper device **60** and **70** according to the modified embodiments will be explained. In FIGS. **6**A, **6**B, **7**A and **7**B, the same portions corresponding to the damper device **50** are referenced with the same numerals or symbols. Regarding the damper device **60** according to the first modified embodiment, the shapes of the restricting surface **62***b*, the elastic body **63***b* and the relief portion **62***f* are different from those of the damper device **50**.

As shown in FIG. **6**A, the restricting surface **62***b* includes an annular projection bottom surface **62***b***1** having a step with a height F_2 in the A-axis direction at a central portion of the annular bottom wall of the large diameter portion accommodating portion **52***a* in a radial direction. The elastic body **63***b* includes an annular recessed portion **633***b***1** at a central portion of the one side end surface **633***b* in a radial direction and the annular recessed portion **633***b***1** is engaged with the annular projection bottom surface **62***b***1**. The inner peripheral surface side wall portion forming the annular recessed portion **633***b***1** is internally in contact with the step surface of the projection bottom surface **62***b***1**. The relief portion **62***f* is provided continuously inwardly in a radial direction from the projection bottom surface **62***b***1** and is provided as a recess having a stepped shape area relative to the projection bottom surface **62***b***1**. The relief portion **62***f* has a bottom surface **622** facing to the end surface **531***d* of the cylindrical portion **531**. The inner peripheral surface **621** of the relief portion **62***f* corresponds to the stepped surface at the inner peripheral side of the projection bottom surface **62***b***1**. The diameter of the inner peripheral surface **534** (**534***a*) of the elastic body **63***b* which enters into the inner peripheral surface **621** and the area of the relief portion **62***f* is larger than the diameter of the outer peripheral surface **531***b* of the cylindrical portion **531**. The relief portion **62***f* is formed so that the end portion **531***c* of the cylindrical portion **531** can advance further to the opposite side of the large diameter portion than the projection bottom surface **62***b***1** in the A-axis direction.

As shown in FIG. **6**B, the impact receiving member **53***a* according to the first modified embodiment receives the impact force and is displaced by the distance "$X_2+\Delta X_2$". The end portion **531***c* of the cylindrical portion **531** advances into the relief portion **62***f* by the displacement distance ΔX_2 and the end surface **531***d* of the cylindrical portion **531** keeps the non-contact state with the large diameter portion housing **62** of the housing **22**. The impact receiving member **53***a* is restricted from relative movement by the elastic body **63***b* which has been filled in the compression space SΔx relative to the large diameter portion housing **62** (housing **22**). Thus, the same effect with the effect achieved by the damper device **50** can be achieved by the impact absorbing member **63** of the damper device **60** of this embodiment.

The damper device **70** according to the second modified embodiment differs from the damper device **50** in the structure of the relief portion **72***f*. As shown in FIG. **7**A, the relief portion **72***f* is formed in a space area between the inner peripheral surface **721** of the shaft accommodation portion **52***e* and the outer peripheral surface of the rack shaft **21**. The relief portion **72***f* has an inner peripheral surface **721** which inner diameter is larger than the outer diameter of the outer peripheral surface **531***b* of the cylindrical portion **531**. The relief portion **72***f* is formed so that the end portion **531***c* of the cylindrical portion **531** can advance further to the opposite side of the large diameter portion than the restricting surface **52***b* in the A-axis direction.

As shown in FIG. **7**B, the impact receiving member **53***a* according to the second modified embodiment receives the impact force and is displaced by the distance "$X_3+\Delta X_3$". The end portion **531***c* of the cylindrical portion **531** advances into the relief portion **72***f* by the displacement distance ΔX_3 and the end surface **531***d* of the cylindrical portion **531** keeps the non-contact state with the large diameter portion housing **72** of the housing **22**. The impact receiving member **53***a* is restricted from relative movement by the elastic body **73***b* which has been filled in the compression space S Δx relative to the large diameter portion housing **72** (housing **22**). Thus, the same effect with the effect achieved by the damper device **50** can be achieved by the impact absorbing member **73** of the damper device **70** of this embodiment.

The invention is not limited to the embodiments explained above. For example, according to the above embodiments, upon receipt of an excessive impact force, under the state before the end portion **531***c* of the cylindrical portion **531** enters into the relief portion **52***f*, **62***f* and **72***f*, the elastic body **53***b*, **63***b* and **73***b* is filled in the compression space or the rigidity of the elastic body **53***b*, **63***b* and **73***b* is suddenly largely changed. However, before the end portion **531***c* of the cylindrical portion **531** enters into the relief portion **52***f*, **62***f* and **72***f*, the elastic body **53***b*, **63***b* and **73***b* is not necessarily filled in the compression space or is not necessarily suddenly and largely cured. Even under the state that the elastic body **53***b*, **63***b* and **73***b* is not filled in the compression space, as long as the end portion **531***c* of the cylindrical portion **531** enters into the relief portion **52***f*, **62***f* and **72***f* and yet keeping the impact receiving member **53***a* to be non-contact state with the large diameter portion housing **52**, **62** and **72** (housing **22**) and the relative movement of the impact receiving member **53***a* and the large diameter portion housing **52**, **62** and **72** (housing **22**) can be restricted by the deformed elastic body **53***b*, **63***b* and **73***b*, the assurance of the avoiding of the collision between the metal materials can be improved. According to the embodiments as shown in FIG. **4**, the performance of the rubber characteristic is suddenly changed from the characteristic of the line L**1** to the characteristic of the line L**2**. However, the performance is not limited to this. Generally, the material with a rubber like elasticity has a tendency that the larger the compression displacement, the larger the rigidity becomes. However, the performance change depends on the individual rubber materials or the shape thereof. It is also noted that according to the embodiments above, the impact absorbing member **53**, **63** and **73** is assembled to the large diameter portion housing **52**, **62** and **72** (housing **22**). However, the structure that the impact absorbing member **53**, **63** and **73** is installed in the large diameter portion **51** and that the impact body absorbs the impact keeping the elastic body to be in contact with the restricting surface **52***b* and **62***b* can be considered within the scope of the invention.

6. Advantageous Effects of the Embodiments

According to the embodiments above, in the damper device **50**, **60** and **70**, the impact absorbing member **53**, **63** and **73** includes an impact receiving member **53***a* which is equipped with a cylindrical portion **531** facing to the inner peripheral surface **52***c* of the large diameter portion housing **52**, **62** and **72** (housing **22**) and a flange portion **532** extending outwardly in a radial direction from the cylindrical portion **531**, facing to the restricting surface **52***b* and **62***b* and being contactable with the large diameter portion **51** and an elastic body **53***b*, **63***b* and **73***b* provided in an initially set space S_0 formed by the inner peripheral surface **52***c* of the large diameter portion housing **52**, **62**, and **72** (housing **22**), the restricting surface **52***b* and **62***b*, an outer peripheral surface **531***b* of the cylindrical portion **531** and the flange portion **532** and formed by a rubber material or a synthetic resin material having a rubber-like elasticity. The large diameter portion housing **52**, **62** and **72** (housing **22**) includes a relief portion **52***f*, **62***f* and **72***f* defined by an area provided continuously inwardly in a radial direction of the restricting surface **52***b* and **62***b* wherein an end portion **531***c* of the cylindrical portion **531** can be advanced further towards an opposite side to the large diameter portion than the restricting surface **52***b* and **62***b* along in an A-axis direction. When the large diameter portion **51** does not apply an impact force to the flange portion **532**, the elastic body **53***b* is disposed having a gap S_1 through S_3 relative to at least one of the inner peripheral surface **52***c* of the housing **52**, **62** and **72** (housing **22**) and the outer peripheral surface **531***b* of the cylindrical portion **531**. When the large diameter portion **51** applies the impact force to the flange portion **532**, the elastic body **53***b*, **63***b* and **73***b* is compressed in the A-axis direction by the restricting surface **52***b* and **62***b* and the flange portion **532**. Therefore, the elastic body **53***b*, **63***b* and **73***b* is deformed to fill up the gap S_1 through S_3 so that the inner peripheral surface **52***c* of the large diameter portion housing **52**, **62** and **72** (housing **22**), the restricting surface **52***b* and **62***b*, the outer peripheral surface **531***b* of the cylindrical portion **531** and the flange portion **532** are all brought into contact with the elastic body **53***b*, **63***b* and **73***b*. Then the movement of the impact receiving member **53***a* relative to the large diameter portion housing **52**, **62** and **72** (housing **22**) is restricted by the deformed elastic body **53***b*, **63***b* and **73***b*, maintaining a non-contact state of the impact receiving member **53***a* relative to the large diameter portion housing **52**, **62** and **72** (housing **22**) by an advancing movement of the end portion **531***c* of the cylindrical portion **531** into the relief portion **52***f*, **62***f* and **72***f*.

The escaping area for enabling the end portion **531***c* of the cylindrical portion **531** to advance therein when the large diameter portion **51** applies the impact force to the flange portion **532** is ensured by the relief portion **52***f*, **62***f* and **72***f* to surely avoid the contact between the impact receiving member **53***a* and the housing **52**, **62** and **72**. Accordingly, the effect of dampening the impact force transmitted to each component of the device is surely achieved.

According to the above embodiments, when the impact is applied on the flange portion **532** from the large diameter portion **51** under the state before the end portion **531***c* of the cylindrical portion **531** enters into the relief portion **52***f*, **62***f* and **72***f*, the elastic body **53***b*, **63***b* and **73***b* is deformed into a state that the elastic body is brought into contact with all of the inner peripheral surface **52***c* of the housing **52**, **62**, **72** (housing **22**), the restricting surface **52***b*, the outer peripheral surface **531***b* of the cylindrical portion **531** and the flange portion **532** to be filled in the gap S_1 through S_3. Thus, the relative movement of the impact receiving member **53***a* relative to the large diameter portion housing **52**, **62** and **72** is restricted by the deformed elastic body **53***b*, **63***b* and **73***b*. Accordingly, when a relatively frequently generated normal impact force is applied on the flange portion **532**, the relative movement of the cylindrical portion **531** relative to the large diameter portion housing **52**, **62** and **72** is restricted before the cylindrical portion **531** enters into the relief portion **52***f*, **62***f* and **72***f*. Further, when a not frequently generated abnormal impact force is applied on the flange portion **532**, the relative movement of the cylindrical portion **531** relative to the large diameter portion housing **52**, **62** and **72** can be also restricted under the state that the cylindrical portion **531** enters into the relief portion **52***f*, **62***f* and **72***f*. As a result, the reliability of the device adapted to be applied an excessive impact force is increased.

Further, according to the embodiments, the relief portion **52***f* and **62***f* includes the inner peripheral surface **521** and **621** which inner diameter is larger than the outer diameter of the outer peripheral surface **531***b* of the cylindrical portion **531** and the bottom surface **522** and **622** facing to the end surface **531***d* of the cylindrical portion **531**. Accordingly, by performing a simple minimum machining on the large diameter portion housing **52** and **62** (housing **22**), the strength thereof can be maintained without reducing necessary strength and the effect of the invention can be achieved in an economical way.

Further, the steering device ST provided with any one of the damper devices **50**, **60** and **70** of the embodiments above. The steering device ST provided with the rack shaft **21** which is connected to a steered wheels **26**,**26** via tie rods **24** **24** at both ends thereof and is reciprocally movable in an axial direction to turn the steered wheels **26**,**26**, and large diameter portions **51**, **51** provided at both ends of the rack shaft **21**, to which the tie rods are pivotally connected, and the housing **22** for accommodating the rack shaft **21**. Thus, the steering device ST which can achieve the advantageous effects of the damper devices **50**, **60** and **70**.

Obviously, numerous modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the present invention may be practiced otherwise than as specifically described herein.

The invention claimed is:

1. A damper device comprising;

a shaft having a shaft portion and a large diameter portion;

a housing formed in a cylindrical shape and through which the shaft is inserted, the shaft being movable in an axial direction relative to the housing, the housing being provided with a restricting surface facing toward an end surface side of the large diameter portion; and

an impact absorbing member inserted on the shaft portion and disposed between the end surface of the large diameter portion and the restricting surface in an axial direction, wherein the impact absorbing member includes;

an impact receiving member including a cylindrical portion facing to an inner peripheral surface of the housing and a flange portion extending from the cylindrical portion outwardly in a radial direction and facing to the restricting surface and being contactable with the large diameter portion; and

an elastic body provided in a space formed by the inner peripheral surface of the housing, the restricting surface, an outer peripheral surface of the cylindrical portion and the flange portion and formed by a rubber material or a synthetic resin material having a rubber-like elasticity, and wherein,

the housing includes a relief portion defined by an area provided continuously inwardly in a radial direction from the restricting surface, wherein an end portion of the cylindrical portion can be more advanced towards an opposite side to the large diameter portion than the restricting surface along in an axial direction;

when the large diameter portion does not apply an impact force on the flange portion and the elastic body is in a non-deformed state, the elastic body is disposed having a gap relative to at least one of the inner peripheral surface of the housing and the outer peripheral surface of the cylindrical portion and the end portion of the cylindrical portion of the impact receiving member is disposed away from the restricting surface in the axial direction and toward the large diameter portion by a predetermined distance; and

when the large diameter portion applies the impact force on the flange portion, the elastic body is compressed by the restricting surface and the flange portion in an axial direction to be deformed into a state that the elastic body is brought into contact with all of the inner peripheral surface of the housing, the restricting surface, the outer peripheral surface of the cylindrical portion and the flange portion to be filled in the gap, and the impact receiving member is restricted from the relative movement relative to the housing by the deformed elastic body when the end portion of the cylindrical portion is advanced into the relief portion and the impact receiving member keeps a non-contact state with the housing.

2. The damper device according to claim **1**, wherein,

when the impact force is applied on the flange portion from the large diameter portion and under the state before the end portion of the cylindrical portion enters into the relief portion, the elastic body is deformed into a state that the elastic body is brought into contact with all of the inner peripheral surface of the housing, the restricting surface, the outer peripheral surface of the cylindrical portion and the flange portion to be filled in the gap; and wherein

the impact receiving member is restricted from the relative movement relative to the housing by the deformed elastic body.

3. The damper device according to claim **1**, wherein,

the relief portion has an inner peripheral surface which inner diameter is larger than an outer diameter of the outer peripheral surface of the cylindrical portion and a bottom surface facing to an end surface of the cylindrical portion.

4. A steering device provided with the damper device defined in claim **1**, wherein,

the steering device includes;

a rack shaft as the shaft, which is connected to steered wheels via tie rods at both ends thereof and is reciprocally movable in an axial direction to turn the steered wheels, and large diameter portions provided at both ends of the rack shaft as the large diameter portion, to which the tie rods are pivotally connected; and

a housing for accommodating the rack shaft as the housing.

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